Advances in Home Canning

by EDWARD W. TOEPFER and HOWARD REYNOLDS

AMERICAN housewives canned more than 4 billion cans and jars of food in 1943, and nearly 3½ billion quarts of food in 1944. The latter represented nearly one-half of the canned vegetables and two-thirds of the canned fruits that were available for civilian consumption that year. The market value of the canned foods exceeded a billion dollars a year. But much of it (45 million containers of the 4 billion put up in 1943) spoiled. The development of processes for home canning that will prevent such spoilage and give improved products is discussed here.

The process of preserving foods by canning was developed by Nicholas Appert, a French confectioner, less than 150 years ago. Neither Appert nor the scientists of his day knew why foods acquired the property of keeping after being heated in sealed containers. It was almost 50 years after Appert's discovery that Pasteur demonstrated that micro-organisms were the real cause of fermentation, putrefaction, and decay. With his discoveries, the ground work was prepared for developing canning processes on a scientific basis. It could then be shown that canned foods kept because heating destroyed spoilage micro-organisms present in the container and sealing prevented the entrance of others.

Appert used the boiling-water bath for heat treatments, which limited the heating temperature to 212° F. Often, however, the processes failed and the food spoiled. Eventually pressure canners were introduced to obtain the higher processing temperatures that seemed to be required for vegetables and meats. Processes or heat treatments were based on rule of thumb and experience. If foods spoiled, the process-time was increased until spoilage was eliminated or reduced. Such methods were used with reasonable satisfaction until about 1916. Between 1916 and 1922, a series of outbreaks of botulism that resulted in many fatalities in the United States focused attention upon shortcomings of the canning techniques in use. As a result, studies were undertaken to determine scientifically the times and temperatures required to destroy microorganisms causing spoilage of canned foods.

Cultures of *Clostridium botulinum*, the bacterium causing botulism, and other spoilage organisms were isolated and studied. It was found that many of these organisms would remain alive after heating for 5 to 6 hours or longer in boiling water. Bacteriologists also learned that bacteria subjected to lethal heat do not die instantly—both time and temperature are factors.

Since the object of the processing or heat treatment is to destroy all spoilage organisms within each container of food, information regarding the rate at which the temperature rises in the slowest heating part of the container was recognized as necessary. Studies of the penetration of heat, such as those reported by C. A. Magoon and C. W. Culpepper of the Department in 1921, were therefore undertaken. Foods were prepared and packed in cans or jars with thermometers or other temperature-measuring devices placed in the slowest heating spots. Data were obtained showing the temperature in the container at each instant during the process. Such heat-penetration data when combined with information on the time required to destroy spoilage bacteria at various temperatures provided the basis for computation of bacteriologically sound processes for canning.

W. D. Bigelow, G. S. Bohart, A. C. Richardson, and C. O. Ball in 1920 first solved the problem of applying the foregoing type of bacteriological and physical data to the calculation of thermal processes for canned foods. Later, Dr. Ball developed more flexible mathematical methods for thermal-process calculations. Further modifications and improvements were made by F. C. W. Olson and H. P. Stevens in 1939 and by O. T. Schultz and Mr. Olson in 1940.

Commercial processes for canning low-acid foods have been established largely by thermal-process calculations based on a reasonably adequate background of information, built up during years of research in laboratories of the can-manufacturing companies and the National Canners Association and in college and university laboratories aided by funds provided by the industry.

But the problems of home canning have not been solved so successfully. Much of the spoilage in 1943 was undoubtedly due to understerilization that resulted from the use of inadequate processes. Water-bath processes for low-acid foods continue to be recommended by some distributors of information on home canning and are still widely used. But research in bacteriology has shown that they are not adequate to destroy resistant spoilage organisms that may be present.

Water-bath processes are successful when resistant organisms are absent, but fail in their presence. This fact has often been demonstrated to home canners by outbreaks of gross spoilage after canning by methods that had been used successfully in previous years. It is on that basis that all canning technologists agree that only properly developed steam pressure processes are adequate to guarantee nonspoilage of low-acid foods.

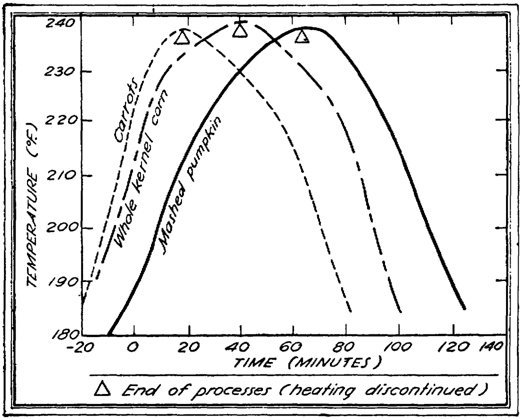
Because research on processes for home canning has been limited, pressure processes recommended for use by home canners generally have been derived from commercial ones, often by arbitrarily increasing the processing time to provide additional factors of safety. Since there are many differences in home and commercial canning equipment and techniques, the arbitrary adaptation of commercial processes to home conditions is questionable. Foods that are home-canned in glass containers have long cooling periods, which add to the sterilizing values of processes; slower heating times add further to the thermal value of equal processing times. Improper evaluation of these factors frequently has resulted in the use of processes for home canning greatly in excess of those required.

Products home-canned in the steam-pressure canner frequently are overcooked and unattractive in comparison with the commercial products. To improve the processes for steam-pressure canning, more facts were needed on the effect of heating and cooling times on the sterilizing values of processes, on the rates of heat penetration from which sterilizing values for different processes are calculated, and on the bacteriological conditions likely to exist during home canning procedures.

On the basis of existing bacteriological information about the numbers and kinds of bacteria that might be encountered and their thermal behavior, it is possible to make a proper evaluation of the effect of home equipment and techniques from heat-penetration data.

Problems of wartime steam-pressure canners, jars, jar rings, and closures were added to the basic physical and bacteriological problems specifically related to home canning. In order to help meet urgent equipment problems, two studies were carried out by the Bureau of Human Nutrition and Home Economics.

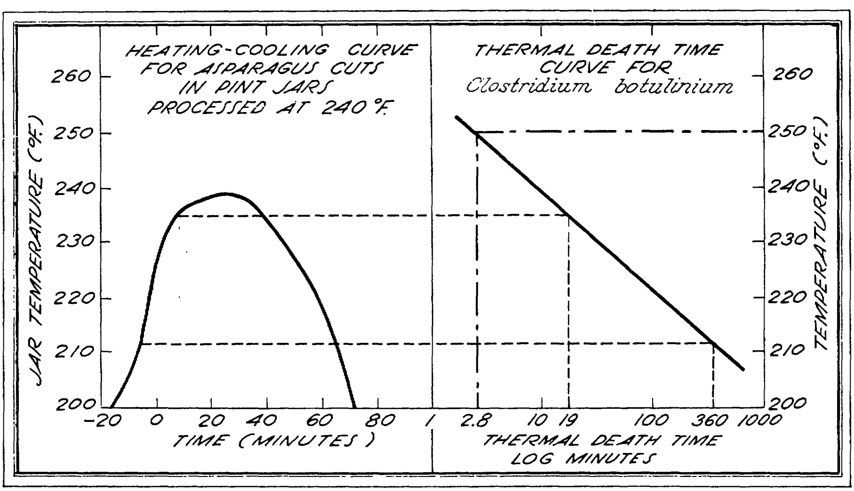
Jar rings had contained 10 to 15 percent crude rubber, for which either new rubber compounds or reclaimed rubber would have to be substituted. The National Bureau of Standards cooperated in a study made to measure the physical and chemical properties of jar rings of different compositions and to correlate such data with the results of practical canning tests. Methods were developed to determine the sealing performance of jar rings under conditions of home canning. Within the limits of the tested irregularity of 0.02 inch in the sealing surfaces expected to be overcome by a ring in order to make a seal, the methods showed that rings made of a suitable reclaimed rubber or 5 percent crude rubber, plus reclaimed rubber, maintained a good vacuum on freshly processed and on stored jars.



Studies have been made to determine the heat-penetration curves of typical fast, medium, and slow-heating vegetables in pint jars. The results are shown here.

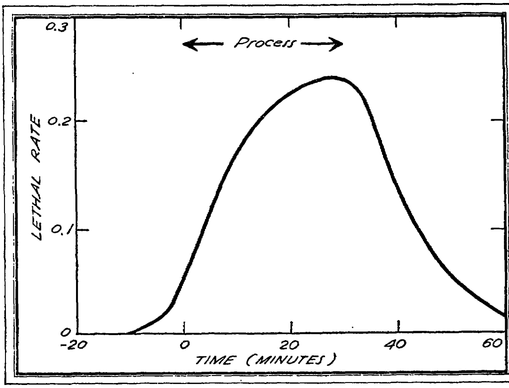
The introduction of enamel on steel for aluminum in the construction of steam-pressure canners raised the question of the effect of different heating and cooling times on the sterilizing value of processes for vegetables in glass jars. Two enameled steel models and seven models of cast-molded, and sheet or pressed aluminum were included in the study. Each was designed to process 7 quart jars of food. The resulting data showed that, under standardized operating conditions, sterilizing values obtained by processing in canners of different materials, construction, design, and having the same container capacity (7 quart jars) are, for practical purposes, equivalent.

A few studies on home-canning procedures have been reported. W. B. Esselen, Jr., and R. G. Tischer of Massachusetts State College calculated processes for home canning from heat-penetration data. In two instances the processes were checked by inoculated packs. Their results indicated



This chart gives the relationship between container temperature and the thermal death time of a known spoilage organism.

that home canning processes at 240° F., as now recommended, may be more severe than necessary. The increased sterilizing effect resulting from slow cooling in glass jars was recognized. The information presented in these and previous reports was, however, inadequate for making general recommendations with respect to processes for home canners.

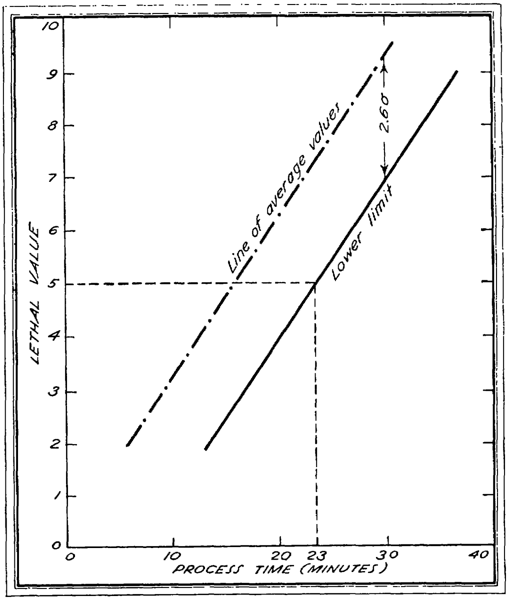


The lethality curve shown in this chart is for asparagus cuts in pint jars that were processed at 240° F.

Because of the lack of basic information, our Bureau undertook studies to obtain adequate data for the development of such processes. In making the investigations, the general methods developed for establishing commercial processes were used. They were modified as necessary to adapt them to the procedures and equipment commonly used in the home. Essentially three steps are involved in developing a process for each individual product. The first step is that of obtaining adequate information on rates of heat penetration. Second, the heat penetration data are used to calculate process times adequate to destroy *Clostridium botulinum* or other spoilage organisms of known heat resistance. Finally, calculated processes are checked by inoculated packs.

Heat-penetration data were obtained by packing the foods into containers carrying temperature-measuring devices. The foods were prepared and packed as they would be in the home. A thermocouple, a heat-sensitive instrument, was sealed into each container, with the temperature-measuring part placed at the slowest heating point. The containers were then placed in a home-type pressure canner equipped so that wire leads of the thermocouples could be passed through the lid for connection with a temperature recording device. The canner was closed and the containers of food processed in the usual manner; during the processing period the temperature of each container carrying a thermocouple was recorded continuously. At the end of the processing time the temperature recording continued until the containers were cool. Such heat penetration data were obtained from 12 or more of each of four types of containers (pint and quart glass jars, No. 2 and No. 2½ tin cans) for every product studied.

Rates of heat penetration vary widely with the size of the container, the kind of food, the size of the pieces of food, and the solidity of the pack. Dif-



Here is shown the process time-lethal value for asparagus cuts in pint jars.

ferences in the rates of heating and cooling of sliced carrots, whole-kernel corn, and mashed pumpkin in pint jars are shown in the chart at the top of page 790.

The data on heat penetration were combined with those on the thermal-death times of known spoilage organisms in order to calculate adequate processes. The temperature at any instant during the heating and cooling of a food can be related to the thermal-death time required for the destruction of the spoilage organism.

Thermal-death times so determined for a series of points along the heating-cooling curve are used to calculate corresponding lethal (death) rates. These rates are then plotted against heating and cooling times to give a lethality curve. When properly plotted, this curve shows the combined destructive effects of heating, holding, and cooling temperatures of the given process. This is known as the lethal value of the process. An adequate process is one which yields a lethal value equal to the thermal-death time of the spoilage organism at 250° F. This value for *Cl. botulinum* is 2.8 minutes.

These graphical-mathematical calculations are carried out with the data from each individual container used to follow rates of heat penetration for each kind of food. Such information is obtained for at least three processing times in order to have the data required for choosing a process that is adequate without being excessive. The next step is to plot the calculated lethal values to give a process-time, lethal-value curve from which the time required to yield a process with a desired lethal value can be read directly.

Heat-penetration data from a number of containers at each of the three process times were used for construction of the average time-lethal value curve. Because of the unavoidable variation in the factors that affect the rate of penetration of heat into canned foods during processing, the sterilizing values obtained from these containers of the same food given the same process, differed. The variation must be taken into consideration in calculating the processes. In a normal distribution, the data will vary about the average or mean value, half of the items falling above and half below the average. Thus, if only the average values were used to construct the time-lethal value curve to be used in determining required process time, the chances are that one jar in two would be underprocessed.

In order to fix a lower limit below which there is little chance that spoilage would occur among the processed jars, a line is drawn parallel to and at a distance of 2.6 times the standard error of estimate of the data below the line of average values. Assuming normal distribution of process values, the probability of an individual container having a process value below the lower line is only 0.005. Process times required in practice to yield the desired process values may be read from the lower curve, as illustrated by the solid line in the chart on page 792.

Finally, the accuracy of the calculated process must be checked by a trial canning of the food with a known contamination. This was done by the preparation of experimentally inoculated packs processed for varying times. For these checks, vegetables were prepared and packed in pint glass jars; home-canning procedures were adhered to as closely as possible. A minimum of 24 jars were each inoculated with 1 cubic centimeter of a suspension containing 10,000 spores of the test organism, putrefactive anaerobe #3679. This organism produces spores of somewhat greater resistance than does *Cl. botulinum,* and has been widely used for checking commercial processes. The inoculated jars, and at least 12 uninoculated or control jars, were then processed at 240° F. The procedure was repeated for at least three processing times with each product. The processing times used were chosen, on the basis of those calculated, to give 100 percent spoilage with the shortest process, decreasing to zero percent with the longest. The inoculated and control jars were incubated after processing and examined daily for signs of spoilage. After incubation for at least 3 months, remaining nonspoiled jars were examined for survival of the test organism.

After calculation of theoretical processes and completion of the inoculated pack checks, process recommendations were made by consideration of all the data. Processes for 12 vegetables considered adequate on the basis of these investigations are given. In general, the new processes are shorter than the old, the differences being greatest for packs in pint jars. Over-all reductions in process times averaged 38 percent for vegetables in pint jars, with 24, 10, and 12 percent reductions for quart jars, No. 2 tins, and No. 2½ tins, respectively.

This study has resulted in the establishment of processing times and temperatures for the home canning of low-acid foods that will destroy the most resistant spoilage organisms likely to be encountered. Such processes can be attained in reasonable periods of time only by the use of pressure canners or equipment permitting temperatures up to 240° F.

Recommended process times at 240° F. for vegetables in various containers

Vegetable	Glass jars		Tin cans	
	Pint	Quart	No. 2	No. 2½
	Min. at 240° F.	*Min. at 240° F.*	*Min. at 240° F.*	*Min. at 240° F.*
Asparagus, cuts	25	55	20	20
Snap beans	20	25	25	30
Lima beans	35	60	40	40
Beets, sliced	25	55	30	30
Carrots, sliced	20	25	20	25
Corn:				
Whole grain	55	85	60	60
Cream style	85	....	105	....
Okra, cut	25	40	25	35
Peas	40	40	30	30
Pumpkin:				
Cubed	55	90	50	75
Mashed	60	80	75	90
Spinach	45	70	60	75
Summer squash	30	40	20	20
Sweetpotatoes:				90
Wet pack	55	90	75	95
Dry pack	65	95	80	

Further studies on the destruction or inhibition of growth of spoilage organisms in the different vegetable media and the numbers and kinds of such organisms likely to be encountered, may result in changes and possibly reductions in the severity of the processing conditions. Studies on the improvement in methods of preparing the food to standardize the packing conditions that affect the variability of the data may also yield information which would justify changes in the process times calculated from the heat-penetration data as presented in this report. Changes in preparation methods to increase the retention of nutrients and improve the palatability of canned products may bring about different conditions for which new heat-penetration data will be needed.

Reductions in process times at 240° F. from those previously recommended may be expected to improve palatability and nutritive value of home-canned vegetables. The ultimate goal of this work is to present procedures to home canners that will be safe, prevent loss due to spoilage, and yield products that are attractive and good to eat.

THE AUTHORS

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